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A STUDY OF RHUS DIVERSILOBA WITH SPECIAL REFERENCE TO ITS TOXICITY

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Rhus Toxicodendron (L.), *Rhus radicans* (L.), and *Rhus diversiloba* T. & G. form a triad of plants equally regarded with aversion. The general recognition of their deleterious character is evinced in the application of the names *poison ivy*, *poison vine*, and *poison oak*, given to them in various parts of the United States.

Perhaps the earliest mention of these plants in North America is the following description by Captain John Smith in 1609:

The poisonous weed, being in shape but little different from our English yvie; but being touched causeth redness, itchinge, and lastly blysters, the which, howsoever, after a while they passe awaye of themselves without further harme; yet because for the time they are somewhat painefull, and in aspect dangerous, it hath gotten itselfe an ill name, although questionlesse of noe very ill nature.

Long before the birth of Linnaeus, Cornutus in 1635 described the plant as a species of ivy in his work on the plants of Canada (*Hedera trifolia Canadensis* Corn. 96 from Carolina in the British Herbarium).

About 1736 Linnaeus classified this plant as *Toxicodendron triphyllum glabrum*. At the same time he described and named *Rhus radicans*.

In an entry dated October 9, 1748, Peter Kalm gave an extensive and interesting description in his travels in North America of the *Rhus radicans* of Linnaeus. Since that time there have been many accounts of these plants and of their toxic nature.

In 1820, Bigelow described *Rhus radicans* of Linnaeus as having

Ternate leaves, that grow on long semicylindrical petioles. Leaflets ovate or rhomboidal, acute, smooth and shining on both sides, and veins sometimes a little hairy beneath. The margin is sometimes entire and sometimes variously toothed and lobed, in the same plant. The flowers are small and greenish white. They grow in panicles or compound racemes on the sides of the new shoots and are chiefly axillary. The barren [male] flowers have a calyx of five erect, acute segments, and a corolla of five oblong recurved petals. Stamens erect with oblong anthers. In the center is a rudiment of a style. The fertile [female] flowers situated on a different plant, are about half the size of the preceding. The calyx and corolla are similar but more erect. They have five small, abortive stamens and a roundish germ [ovule] surmounted with a short, erect style ending in three stigmas. The berries are roundish and of a pale green color, approaching to white.

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A plant has long appeared in the Pharmacopoeias under the name of *Rhus Toxicodendron*. Botanists are not agreed whether this plant is a separate species from the one under consideration, or whether they are varieties of the same. Linnaeus made them different with the distinction of the leaves being naked and entire in *Rhus radicans*, while they are pubescent and angular in *Rhus Toxicodendron*. Michaux and Pursh whose opportunities of observation have been more extensive, consider the two as mere local varieties; while Elliott and Nuttall still hold them to be distinct species. Among the plants which grow abundantly around Boston, I have frequently observed individual shoots from the same stock having the characters of both varieties. I have also observed that young plants of *Rhus radicans* frequently do not put out rooting fibers until they are several years old and that they seem, in this respect, to be considerably influenced by the contiguity of supporting objects.

The attitude taken by Bigelow has been sustained by later botanists, among them Torrey and Gray (58) who consider *R. radicans* a variety of *R. Toxicodendron*.

Rhus diversiloba was first discovered by Douglas at Fort Vancouver on the Columbia river about 1830. Upon examination of this specimen W. J. Hooker (26), although he considered it "nearly allied, as this assuredly is, to the two preceding species [*R. Toxicodendron* and *R. radicans*]," nevertheless "ventured to consider it distinct." He therefore gave it botanical significance as *Rhus lobata*. To support his conclusion he advances the following reasons:

It's general habit is very different, having erect straight *stems* and numerous small leafy *branches*. The leaflets besides being deeply lobed with acute sinuses are truly ovate, very obtuse, and greatly smaller than in any state of *R. Toxicodendron*, or *R. radicans*, which I have seen; the *panicles*, too, are exceedingly numerous.

A free translation of Hooker's Latin description of the plant is as follows:

Bush erect, 3-4 feet, branches round with the youngest ones pubescent, branches numerous, short, spreading, leafy. *Leaves* long-petiolate, trifoliate, with little leaves ovate, 1-2 inches long, very obtuse, membranaceous, at the base sometimes acute, sometimes rotund or truncate, beneath especially pubescent, deeply and variously lobate, terminate one sub-long-petiolate, each side sub-equally lobate with lobes generally less than 3, with little lateral leaves at the exterior margin more deeply lobate. *Flowers* (male) yellow, in loose racemes, shorter than leaf, longer than petiole. *Bracts* at the base of the branches oblong, ciliate. *Calyx* deeply parted with oblong lappets. *Petals* 5, much longer than the lappets of the calyx, obovate into a tongue evidently with attenuated base, at the back veined. *Stamens* 5, erect, little shorter than petals. *Filaments* subulate. *Anthers* 5, somewhat more greatly ovate, pale yellow, with cells sub-opposite. *Style* small, extending from the center of a platter-shaped disc situated in the bottom of the calyx, margin of the disc elevated, curled.

The next known discovery of *R. lobata* was that of Capt. Beechy (Hooker and Arnott, 27) at San Francisco and Monterey Bay about 1832. These specimens differed in no respect from the more northern ones discovered by Mr. Douglas.

The observations of Nuttall (Torrey and Gray, 58) furthered the botanical knowledge of the plant. He noticed that

Comparison of *Rhus Toxicodendron* (Poison Ivy) and *Rhus diversiloba* (Poison Oak)

	Male		Female	
	<i>Rhus diversiloba</i>	<i>Rhus Toxicodendron</i>	<i>Rhus diversiloba</i>	<i>Rhus Toxicodendron</i>
Panicles:	Light green	Light green	Light green	Light green
Color.....	As many as leaves on flowering shoot, except none in highest or lowest axils.	As many as leaves on flowering shoot, except none in highest or lowest axils.	$\frac{1}{2}$ as many as leaves. Total number about the same as in male (3 to 5)	
Number.....	7 cm. Sharp. 45° 12	3-5 cm. Sharp. 45° 12	3-6 cm. Obtuse, limp. 12	3-4 cm. Obtuse, limp. 5
Length.....	3 lowest, 2 cm.	3 lowest, 2 cm.	2.5 cm.	1.5-2 cm.
Number of side twigs of first order.....	Same as leaf	Same as leaf (3/9)		
Length.....				
Angle with stem.....				
Number of side twigs of first order.....				
Length.....				
Phyllotaxy.....				
Flowers:				
Number.....	4-7 mm.	2-3 mm.	5-10 mm.	1.5-2 mm.
Pedicel length:.....	5-7 mm.	9 mm.	5 mm.	4 mm.
Flower width.....				
Calyx leaves:				
Number.....	5	5	5	5
Length.....	2 mm.	2 mm.	2 mm.	1 mm.
Width.....				
Shape.....	Tongue-shaped	Tongue-shaped	Tongue-shaped	Tongue-shaped
Color.....	Dark green	Dark green	Dark green	Dark green
Petals:				
Number.....	5	5	5	5
Length.....	4 mm.	4 mm.	3 mm.	2 mm.
Width.....	1.5 mm.	2 mm.	1.5 mm.	1 mm.
Shape.....	Elliptical, curved down	Elliptical, curved down	Not curved down as much as male	Not curved down as much as male
Color.....	Light green	Light green		
Stamens:				
Number.....	5	5	5	5
Length.....	2.5 mm.		1.5 mm.	
Anther:				
Variety.....	Introrse, shrunken	Introrse	Introrse, shrunken	Introrse, shrunken
Filament.....	Dirty yellow color		Dirty yellow color	Dirty yellow color
Length.....	2 times as long as anther			

Comparison of Flowers of *Rhus Toxicodendron* (Poison Ivy) and *Rhus diversiloba* (Poison Oak)—Continued

	Male		Female	
	<i>Rhus diversiloba</i>	<i>Rhus Toxicodendron</i>	<i>Rhus diversiloba</i>	<i>Rhus Toxicodendron</i>
Pollen:				
Size.....	1/800 sq. mm. in horizontal area			
Shape.....	Wide 1/3-1/2 of length			
Color.....	Yellow			
Condition.....	Rough with sharp-pointed cells, adhesive		Absent	
Ovules:				
Number.....	1 mm. high			
Size.....	Keg		Egg-shaped	
Shape.....			Fully developed	Fully developed
Color.....			3, of which 2 are rudimentary	3, of which 2 are rudimentary
Condition.....	Rudimentary	Rudimentary		
Carpels.....				
Stigmas:				
Number.....	3			
Size.....				
Shape.....				
Color.....				
Condition.....				

Specimens of *R. Toxicodendron* collected in the Botanical Garden of the University of Pennsylvania.
Specimens of *R. diversiloba* collected at Berkeley, California.

The sterile and fertile flowers of this species (which is very near *R. Toxicodendron*) present some notable differences. The sterile, which is figured by Hooker, has rather deeply lobed leaflets, sometimes in fives and larger flowers; in the fertile the leaflets are almost entire or slightly lobed and the flowers considerably smaller, so that it might readily be taken for a distinct species. The fruit is white, somewhat pubescent and gibbous.

Torrey and Gray (58) summed up the previous knowledge of the plant and renamed it *Rhus diversiloba*, the name by which it is now more commonly known.

The difference between *R. diversiloba* and *R. Toxicodendron* is so small that their proper classification forms a bone of contention between botanists. Those botanists who believe in innumerable species are in favor of their separation, while the more conservative are opposed to it. Greene (21) considers *R. diversiloba* "a peculiar type of *Toxicodendron* belonging exclusively to the Pacific Coast." Engler (15) believes *diversiloba* a subspecies of *Toxicodendron*. The only botanical ground for the separation of the two into different species is a slight difference in the shape of their leaflets (Gray, 17). A three years' study of *Rhus diversiloba* and a recent study of *R. Toxicodendron* in Pennsylvania and Maryland for a year have enabled me to make a personal comparison of the two plants. The tracings of the outlines of mature leaves of both plants (figs. 1, 2) and a tabular account

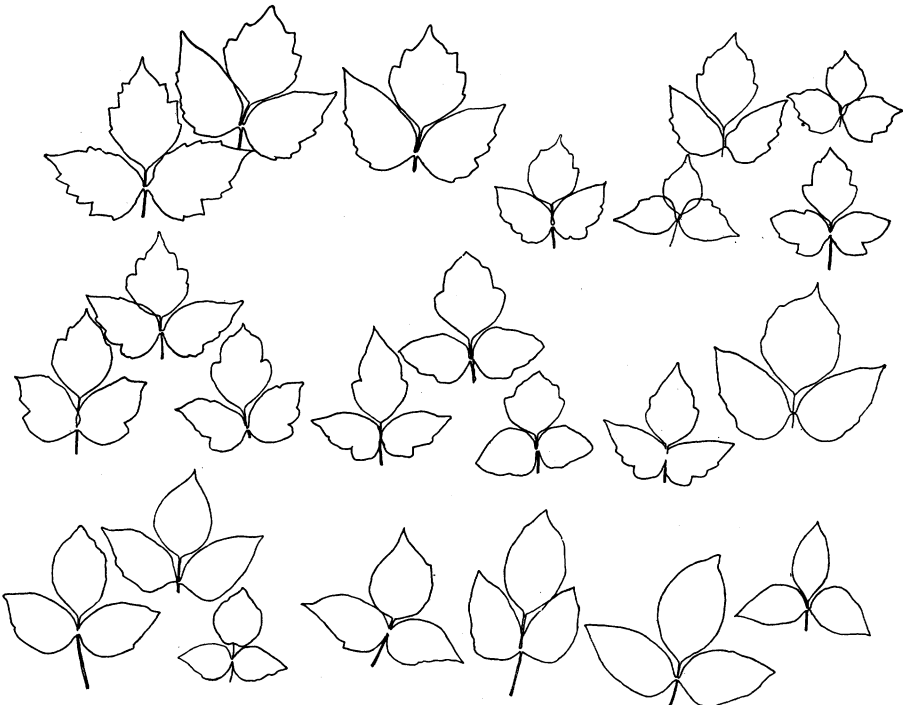


FIG. 1. Tracings of mature leaves of *Rhus Toxicodendron* (Reduced $6\frac{3}{4}\times$).

of the flowers of both plants will permit the reader to decide whether or not there is sufficient difference to constitute a separation into species.

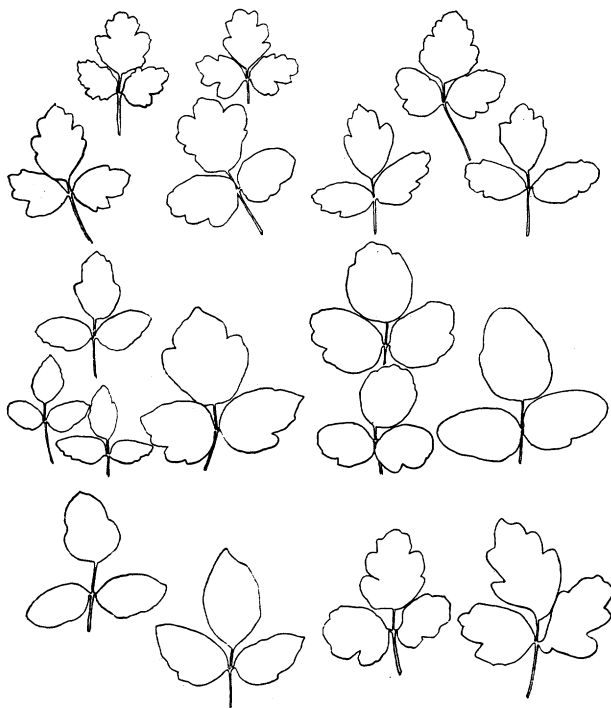


FIG. 2. Tracings of mature leaves of *Rhus diversiloba* (Reduced $6\frac{3}{4} \times$).

GEOGRAPHICAL DISTRIBUTION OF *R. DIVERSILOBA*

The distribution of poison oak includes Lower California north of latitude 29° (Brandegge, 6), Santa Barbara and Santa Catalina Islands (Brandegge, 7), California, Oregon, Washington, Vancouver Island, and British Columbia. The region inhabited by the plant has been approximately defined by citations from botanical literature, sources of herbarium specimens, and places where birds were found that had poison oak seeds in their stomachs. From these data, the territory inhabited by poison oak embraces the Sonoran and lower transition life zones, and excludes the desert and central valley regions of California together with the upper transition and boreal zones.

The inhabited area has an altitude varying from sea level to 6,000 feet above sea level. Hall's (24) observations in the Yosemite Valley make it an inhabitant of the Hetch Hetchy and the low foothills with a maximum altitude of about 4,000 feet. In southern California he noticed it in the San Jacinto Mountains along the North Fork of the San Jacinto river at an altitude of approximately 3,000 feet. I have found it in Cold Water Canyon on the southwest side of Mt. San Antonio in the San Gabriel Range

in southern California at an altitude of 4,500 feet. The lowest and highest regions of California are therefore free from poison oak.

From rainfall data compiled by the United States Government the plant requires an annual rainfall of at least ten inches.

Geographical Distribution of Rhus diversiloba (Poison Oak) According to Literature and Correspondence

Date	Author	Location
1831	Douglas	Common on the outskirts of woods in dry soils in northwest America. Plentiful at Fort Vancouver.
1832	Hooker and Arnott	San Francisco and Monterey Bay.
1845	Lindley and Lyon	Common everywhere in California. An inhabitant of Santa Catalina Island.
1855	Newberry	Common throughout northern California; more rare in the Klamath Basin.
1856	Torrey	Plains and mountains near San Gabriel; Martinez.
1876	Brewer and Watson	From southern California to British Columbia; in California most abundant in the Coast Range.
1878	Wheeler	Common on the Pacific Coast.
1886	Greene	On the north side of Santa Cruz Island.
1886	Lyon	An inhabitant of Santa Catalina Island.
1889	Brandeggee	In Lower California, very abundant about El Rosario.
1890	Brandeggee	Common on San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina Island.
1893	Coville	Found at several points on rocky hillsides in the foothill belt of the western slopes of the Sierra Nevada.
1894	Greene	Copious in the Coast Range hills, preferring cool northward slopes and the banks of streams; absent from the more elevated portions of the Sierra.
1895	Gray	Common throughout California, north to the borders of Washington.
1897	Jepson	Fort Bragg to Sherwood Valley in redwood belt.
1898	Howell	In forests and rocky hillsides, British Columbia to California.
1898	Jepson	Mitchell Canyon, Mount Diablo.
1899	Jepson	Crane Creek and Rosewood, Stiver's ranch.
1900	Jepson	Cedar Creek.
1901	Jepson	Smith Mountains, Palomar, 6,000 feet.
1901	Jepson	Kaweah Range, north slopes and moist places.
1901	Jepson	St. Helena, climbing redwood.
1901	Jepson	Pine Canyon, Mt. Diablo, shrubs 6 feet high.
1902	Chestnut	Common in valleys and on hillsides everywhere throughout Mendocino County.
1902	Jepson	Givin Mine, Calaveras County, 1,100 feet altitude. Shrubs 12 and 13 feet high. Schoolhouse Creek, Ft. Bragg, Cahto. Redstone Park. Hawley School, Willits. Fort Seward, Ranch Ridge, Humboldt County, 3,000 feet. Abundant. Idolwild (near Camp Grant), Humboldt County. Climbs up redwood trunks 90-100 feet. Hawkins Bar (Dyer's ranch). Usal to Cottonaby Creek.

- 1903 Greene.....A peculiar type of *Toxicodendron* belonging exclusively to the Pacific Coast.
- 1903 Jepson.....Along fences in Vacaville.
Vacaville to Twin Sister's Peak. Vacaville Rock Peak.
- 1906 Piper.....Washington to California in the coast regions. Humid transition zone.
- 1907 Jepson.....Cudahay Trail to Dutch Henry's on Klamath River, 2,500–4,000 feet, below fir zone, only along river.
- 1909 Parsons.....Throughout California, save in the high Sierras.
- 1909 Jepson.....Pepperwood, Humboldt County, in redwood trees.
Hetch Hetchy (3,700 feet).
- 1910 Jepson.....Belden, 2,000 (approximate) feet.
Half Moon Bay.
- 1911 Jepson.....Arroyo Seco, Monterey County, altitude 100–500 feet.
Napa Range near Atlas Peak.
- 1911 Abrams.....Frequent in chaparral belt throughout southern California.
- 1911 Muir.....Common throughout the foothill region up to a height of at least 3,000 feet above sea level.
- 1911 Jepson.....Found in Coast Range and foothills of the Sierra Nevada, widely distributed and often abundant.
- 1912 Hall.....Confined to lower end of Yosemite Valley, and to the Hetch Hetchy and low foothills.
- 1912 Jepson.....Nelson, middle Tule River, altitude 4,760 feet.
Saratoga, Santa Clara County, altitude 600 feet.
- 1916 Hall.....Merced Canyon, not rare to 3,200 feet altitude. West of Wawona at 4,500 feet. Small.
In Santa Cruz Mountains, dominant shrub Alma to summit, especially in redwood belt.
- 1916 Sanborn.....Abundant in the hills about Eugene, and all through the western part of Oregon.
- 1916 Crawford.....In mountain canyons and valleys from sea level to about 7,000–7,500 feet elevation.
Very common throughout Pomona Valley and all the valley regions between San Bernardino and the coast.
- 1916 Parish.....Grows to some extent in damp soil in San Bernardino Valley, altitude 1,000 feet, and abundantly in the canyons of the southern slope of the San Bernardino Mountains up to 3,500 feet altitude at least. Does not grow in the higher mountains nor in either the Mojave or the Colorado Desert.
- 1919 Jepson.....Dunsmuir to Castle Rock Station along Sacramento River, 2,200 feet altitude.

Locations where Birds which had eaten Rhus diversiloba Fruit were Collected

CALIFORNIA

Alhambra
Arroyo Valley Creek
Berkeley
Berryessa
Camp Meeker
Chico, Tehama County
Claremont
Cull Canyon
Guadalupe

Pinto Mountains
Rio Dell, 15 miles southwest
San Antonio Canyon
San Fernando
San Jose
Santa Clara County
Santa Monica Mountains
Santa Rosa
Sierra Morena, 6 miles

Haywards
Mt. Diablo
Northwest of Pasadena
Palo Alto
Pasadena
Payne P. O., Tehama County
Petrolia

Simol
Smith Creek
South of Palo Alto
Stewart's Ranch
Volta
Watsonville

OREGON

Ashland
Bybee's Bridge

Coquille
Los Gatos

WASHINGTON

Garfield County

(The above list was communicated to me by Dr. E. W. Nelson, Acting Chief, Biological Survey, U. S. Department of Agriculture.)

Distribution of Rhus diversiloba According to Sources of Herbarium Specimens

CALIFORNIA

Alpine, San Diego County, Mearns 4019.
Alum Rock Springs, vicinity, Santa Clara County.
Big Chico Creek Canyon, Butte County, altitude 250 feet, A. A. Heller.
Black Mountain, Santa Clara County, Elmer 4785.
Blochman's Ranch, Mariposa County, Alice Eastwood.
Cantara, Siskiyou County, Alice Eastwood.
Carmel, Monterey County.
Casitas Pass, Ventura County, altitude 1000 feet.
Chico, near, Palmer 2060.
Clayton, Contra Costa County, Brewer 1068.
Cow Creek Mts., Shasta County.
Folsom.
Forest Ranch, 1897, Mrs. R. M. Austin 1801.
Fort Tejon, vicinity, Kern County.
Foster Park, Ventura County, Alice Eastwood.
Gasquet, Del Norte County, Alice Eastwood.
Havilah, Grinnell 362.
Healdsburg, Sonoma County.
Kings Canyon, Lieber Mts., Los Angeles County.
Little Chico Creek, Austin 749.
Los Gatos foothills, 1904, A. A. Heller 7327.
Los Tronus Creek, San Mateo County.
Mendocino, near, H. E. Brown 750.
Monterey, Bailey.
Monterey, Botta in Mus. Herb., Paris.
Mount Diablo, Alice Eastwood.
Mutair Flat, Ventura County.
New York Falls, Amador County, altitude 2000 feet.
North Fork and vicinity, Griffiths 4531.
Oroville, Table Mt., 8 miles north of, Butte County.
Pacific Grove.
Petrified Forest, Alice Eastwood.
Palo Alto, foothills near, Santa Clara County.
Pasadena, Jones 3206.
Red Reed Canyon, Ventura County.

Round Valley, Mendocino County.

St. Helena, vicinity.

San Clemente Island, Mearns 4048.

San Diego, canyons near, J. J. Hernleer.

San Francisco, Lone Mt. Cemetery.

San Franciquito Creek, San Mateo County.

San Jacinto Mts., shade along north fork of San Jacinto River, altitude 3000 feet, H. M. Hall.

Santa Barbara, Elmer 3940.

Santa Clara County, J. J. Hernleer.

Santa Cruz, Marcus E. Jones.

Santa Cruz Island, Stanford Herbarium.

Santa Cruz Mountains, 1903, N. L. Gardner.

Sausalito Hills, Kellogg and Herford 332.

Savage Hill, Amador County, altitude 2200 feet, Hansen 53.

Shasta River, near mouth, Siskiyou County.

Stanford University, Santa Clara County, Rutter 163.

Stanford foothills, Baker's collection no. 547.

Sulphur Banks, Lake County.

Sulphur Mountain Spring, Sulphur Mountains, Abrams and McGregor 46.

Sulphur Mt. Spring, Ventura County.

Table Mt., Butte County, altitude 600 feet.

Tamalpais.

Tassajara Hot Springs, Elmer 3178.

Topsajoin (?) Hot Springs, Monterey Co.

Vaca Valley, Solano County.

OREGON

Ashland, Stanford Herbarium.

Azalea Creek, Mears.

Cascade Mts., Moseley in Kew Herbarium.

Columbia River, between 46° and 49° latitude.

Columbia River, rocky places, Ethel I. Sanborn.

Coos Bay, House 4746.

Corvallis, 1898, Moses Craig.

Dallas.

Deschutes River, 1885, Thomas Howell.

Jackson County, along Walker Creek, altitude 3300 feet, Applegate 2339.

Lyall in Kew Herbarium.

Portland, 1885, L. E. Henderson.

Portland, open hillsides, Ethel I. Sanborn.

Portland, Walpole 44 and 8.

Portland, rocky hillsides, 1903, J. Lunell.

Rocky Butte, Multnomah County, Ethel I. Sanborn.

Umpqua Divide, head of Elk Creek, altitude 1500 feet, Leiberg 4190.

Umpqua River, east fork of North Fork, 6-10 miles east of Peel, altitude 1500 feet, Applegate 2700.

Umpqua-Rogue River Divide, dry hillsides, Ethel I. Sanborn.

Wasco County, 1896, L. F. Henderson.

WASHINGTON

American Lake, south of Tacoma, F. S. Hall.

Orchard Point, Kitsap County, F. L. Pickett.

Seattle, F. L. Pickett.

Seattle, F. S. Hall.

Tacoma, seashore and bluffs, F. L. Pickett.

Union City, F. L. Pickett.

VANCOUVER ISLAND

Vancouver Island, Tolmie, Douglas in Kew Herbarium.

Victoria, near Swan Lake and on the west side of Seanch Arm, J. R. Anderson.

THE ORIGIN AND OCCURRENCE OF THE POISON

The freshly exuded resinous sap of *R. diversiloba* has long been known to be capable of producing dermatitis when applied to the skin. With this in mind, investigations were carried out to see whether the poisonous portions of the plant are limited to those portions that contain the resin canals.

Microscopical examination of the staminate flower shows four resin ducts in the receptacle and pedicel, one in each petal, but no resin ducts more than half-way up the basal filaments of the stamens. Realizing the absence of resin canals in the anthers, it was thought perhaps the pollen might be non-toxic. (See Pl. II, *D*.) The pollen was collected by shaking the flowers over a glass funnel to the stem of which a test tube was attached. This pollen was found to be non-poisonous when rubbed into the skin of an individual sensitive to the poison. An alcoholic extract of the pollen was non-toxic, nor did the pollen or the alcoholic solution assume a dark brown color when treated for five minutes with potassium hydroxide as does the poison. It is concluded, therefore, that the pollen is incapable of producing dermatitis. Similar non-toxic results have been obtained with the pollen of *Rhus vernicifera* by Inui (30), with that of *R. Vernix* by Warren (59), and with that of *R. Toxicodendron* by Rost and Gilg (50).

C. Schwalbe (51) considered the poison of *R. diversiloba* to be excreted from glandular hairs on the surface of the plant. As the resin canals are not connected with the epidermis or with the trichomes, it was considered that these like the stamens might also be non-toxic. Two different forms of trichomes have been noticed on the plant, similar morphologically to those found by Möbius (42) on *R. vernicifera* and by Rost and Gilg (50) on *R. Toxicodendron*; namely, a unicellular or multicellular needle-shaped hair, and a multicellular club-shaped hair (Pl. II, *F*). Morphologically the club-shaped hairs seem to be glandular; first, the upper multicellular portion is sharply marked off from the basal portion, which resembles a stalk; second, the upper portion has thinner walls than the basal portion; third, they are found mostly on the young, rapidly growing organs of the plant, especially on the floral region and the leaves, less on the green stems, and hardly at all on the woody portions.

When the green stem, pedicel, or main ribs of the leaf, which are covered with trichomes, are rubbed on skin sensitive to the poison, no dermatitis results. Care must be taken, however, that the epidermis of the plant is not broken severely enough to cause the resinous sap to exude.

The fresh green leaves were placed in a finger bowl and soaked in room

temperature in 95 percent alcohol for ten minutes. The leaves had been examined first under a hand lens to make sure that through possible injury no resinous sap was on the surface. When placed in the finger bowl the sap was prevented from running down the pedicel from the cut end into the alcohol. The leaves when taken out of the alcohol had lost their gloss. The pale yellowish alcoholic solution remaining was concentrated by boiling in an open beaker. It was found to be non-toxic. It was not darkened by potassium hydroxide nor did it respond to other chemical tests for the poison. These results indicate that neither the plant trichomes nor their exudate are poisonous.

The cork cells of the older stem were likewise found to be non-toxic either when the branch was rubbed on the skin or when an alcoholic solution was made of scrapings from the outermost cork cells of a branch as thick as a man's wrist.

As no resin ducts were seen on a microscopical examination of the pith of a one-year-old stem of the poison oak nor in the woody stem, experiments were undertaken to determine their toxicity. The bark was carefully removed from the pith, a clean knife being used to shave off the outermost portions of the pith. The pith was then cut up in small portions and extracted in a Soxhlet apparatus with hot 95 percent alcohol. This alcoholic solution when concentrated gave neither a physiological test for the poison nor any of the chemical tests.

A similar experiment carried on with the woody xylem gave corresponding results.

SUMMARY

1. The fresh sap emulsion is the only part of the plant capable of producing dermatitis.
2. Those portions of the plant that do not contain the resin canals do not normally have this kind of toxic effect.
3. The non-toxic portions are the anthers, pollen, xylem, epidermis, cork cells, and trichomes.

LIABILITY TO POISONING RELATIVE TO GROWTH OF PLANT

At just what stage in its life the *Rhus diversiloba* plant first contains its irritant poison has not yet been determined. After the plant has become several years old, however, all parts except the xylem, cork cells, epidermis, and trichomes are toxic. Although many persons know the sap of the stems and leaves to be poisonous, yet there are some who do not consider the sap of the roots toxic. Such is the case, however, as is attested by persons who have come in accidental contact with the broken roots of the plant while digging out other botanical specimens (Kunze, 35; Stirling, 55). The poisonous action of the roots might be expected from their structure, as they have numerous vertical resin canals encircling the xylem (Pl. II, C).

The resinous sap of the stems and roots retains its toxicity probably without much variation in amount or in the degree of virulency throughout the year. This is evinced not only by citations from literature (White, 61; Beringer, 3) and by statistics (table 1), but also by experiments conducted with the sap by the writer.

The virulency (the liability to cause poisoning) of the plant varies with the different seasons of the year in accordance with the stage of growth of the leaves, stems, and flowers. When the first leaves of the plant are unfolding in the spring they are very turgescient and easily injured. Analogously, the growing stems are less resistant than the mature stems. The mature leaves of the plant are not nearly as easily injured. Of the mature leaves, those that grow in the shade have a weaker structure than those which develop in the sun. From this fact one might expect the shade leaves to be less resistant to injury.

The amount of poison in the plant varies with the capacity of its resin canals. Of this variation in amount, that of the stems and leaves is most commonly effective in the index of virulency. The leaf area undoubtedly makes its greatest increase in spring between the time when the leaves begin to unfold and the time when the flowers open. From this latter time the leaf area of the plant is nearly constant until the leaves begin to fall in autumn. Four weeks are generally required for the full development of a leaf. The flower and leaf buds begin to expand simultaneously, but the leaves soon expand more rapidly and reach maturity before the flowers open (Pl. II, B). The staminate and pistillate plants begin to bloom at about the same time. At Berkeley, California, but few of the flowers were open April 4, 1915. The next spring the plants near the Greek Theatre, at Berkeley, bloomed mostly between March 22 and May 1. Either the amount or the virulence of the poison in the autumn leaves is less than that of the normal mature leaves. Of the autumnal leaves the red are less toxic than the yellow, and when the leaves have finally withered and fallen they are non-toxic (McNair, 40).

Inui (30) has noticed that the amount of secretion of *R. vernicifera* is influenced by the conditions of light and atmospheric humidity. In potted plants the secretion lessened when carbon assimilation was hindered. Similarly, secretion was greater in damp than in dry air. This secretion therefore seems to bear a relation to transpiration and hence to turgor. As the degree of turgor varies indirectly with the amount of transpiration, other factors being equal, secretion would be least when transpiration is greatest. Turgor, too, is a necessary accompaniment of growth; flaccid tissues do not grow larger. If those influences which affect *R. vernicifera* have a similar action on *R. diversiloba*, then secretion, and consequently the plant conditions for poisoning, would be greatest during that time of the year when the growth of the plant is most active and the tissues least resistant, namely, in the spring. Obviously enough, when the plant is in

full leaf and when growth has diminished, its resistance to injury will be greater and the liability of poisoning by it less.

The malignancy of the plant may also be considered in relation to its visibility or conspicuity. From this standpoint the virulency of the plant would be indirectly proportional to its conspicuity. The plant is least conspicuous when it is not in leaf, more conspicuous in the spring when the leaves and flowers are expanding, still more easily recognized when in full leaf, and most likely to be observed when its leaves have assumed their bright autumnal colors.

The virulency of the plant may be summarized according to its toxic portions, the virulency of the resinous sap, the turgescence and ease of fracture of its parts, the conditions of light and atmospheric humidity, and its conspicuity. The liability of poisoning, then, by *R. diversiloba* tissues decreases as follows: immature leaves and flower parts (except anthers and pollen), mature leaves, green stems, young roots, woody stems, and woody roots. According to the amount of poison in the plant, however, virulency would be greatest during the period of full leaf. This factor gives way before the far greater balance of factors just mentioned.

This theoretical consideration of the liability to *Rhus* poisoning from a botanical point of view has its counterpart in clinical statistics. The latter lend analogous evidence to the conclusion that spring has the greatest number of cases, that a sudden decrease in cases occurs during the time of the autumn tints, and the least number of cases takes place during the dormancy of the plant from November until February. It should be noted, also, that in 1915 the greatest number of cases among Berkeley students (table 1) was in March, previous to the opening of flowers about April 4, and that in 1916 the maximum number of cases occurred during February previous to the maximum flowering period (March 22 to May 1) of that year. This evidence contradicts the belief prevalent among many people that the plant is most malignant during its flowering period. Some of the opinions expressed in medical literature in regard to malignancy are as follows: most cases usually in spring (Busey, 9); most noxious at the period of efflorescence (Yandell, 63); most cases in summer and autumn (Park, 46); greatest activity during the flowering season, from May to October (Philadelphia; Blackwood, 5); most virulent July 1 to September 1 (Hubbard, 29); worst in December when buds are coming out and in May when leaves fall (California; Baldwin, 2); poisonous at all seasons of the year (Philadelphia; Beringer, 3); most poisonous when in bloom (Davis, 1897); cases most prevalent at the season of the year when the foliage is beginning to show itself (Cantrell, 10); most poisonous when in bloom (Harriman, 1898); especially virulent just as the buds come in the spring (Thudichum, 56); more active (in New York) during the summer months, the last two months of spring, and the two first months of autumn (Hadden, 22).

TABLE I. Occurrence of *Rhus diversiloba* Dermatitis among University Students, Berkeley, California

Year	Time and Frequency of Occurrence							
	June (Part of Month)		July		August (Part of Month)		September	
	Number		Number		Number	Percent	Number	Percent
1912-13 . . .					2	1.5	13	10.4
1913-14 . . .					0	2.0	1.5 11 24	9.4 9.9
1914-15 . . .					4	2.2	21 35	8.9 11.0
1915-16 . . .					3	1.6	15 16 31	13.2 8.4 8.6
1916-17 . . .					9	5.4	25 4.4 15 40	8.8 15.2 13.3 14.2
1917-18 . . .					4	3.5	27 1.4 16 43	11.5 8.7 10.1
1918-19 . . .	4	5	4	16	3	3.8	8 2.8 18 26	10.2 11.6 10.9
	0	0	0	0	0	1.9	0 0 0	7.6 8.3
	6	6	11	11	1		8 0 0	8

TABLE I. (Continued)

Year	November		December (Part of Month)		January (Part of Month)		February		March	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1912-13.	13	10.4	11	8.8	9	7.2	24	19.3	19	16.1
	9	7.6	11	9.4	3	2.5	21	17.9	42	35.8
1913-14.	11	7.0	14	8.9	8	5.0	22	14.0	61	38.8
	23	14.4	20	12.8	5	3.2	19	12.1	49	31.4
1914-15.	20	11.2	9	5.0	12	6.7	18	10.1	30	16.9
	30	16.6	6	3.3	10	5.5	21	11.6	43	23.8
1915-16.	19	11.5	10	7.3	6	3.6	32	19.5	45	27.4
	14	12.5	4	3.5	3	2.6	40	35.7	23	20.5
1916-17.	26	11.1	12	5.1	8	3.4	34	14.5	61	26.1
	26	14.2	10	5.4	7	3.8	25	13.7	29	15.9
1917-18.	13	16.6	8	10.2	7	8.9	8	10.2	12	15.3
	24	15.4	9	5.8	15	9.6	19	12.2	29	18.7
1918-19.	2	16.0	17	8.0	15	9.7	27	11.2	41	17.0
	11	13								

TABLE I. (Continued)

Year	April		May (Part of Month)		Total Annual			Annual Summaries		Percentage of Students Affected by <i>Rhus diversiloba</i> Treated at University Infirmary
	Number	Percent	Number	Percent	Number	Percent	Total Students in Attendance at Berkeley†			
1912-13.	18	14.5	9	7.2	124	99.4	2821	4.03	5.18	
	11	9.4	5	4.2	117	96.6	1846	6.33		
1913-14.	19	12.1	0	0	157	99.7	3285	4.77	6.16	
	6	3.8	0	0	156	99.0	2064	5.349		
1914-15.	35	19.7	9	5.0	177	99.3	3454	5.848	6.32	
	27	15.0	2	1.1	180	99.5	2394	7.52		
1915-16.	No record		No record		164	100.8	3491	4.69	4.41	
	28	12.0	7	3.0	112	99.6	2706	4.13		
1916-17.	37	20.3	9	4.9	233*	99.9	3751	6.21	6.19	
1917-18.	13	16.6	0	0	182*	99.4	2944	6.18		
	23	14.8	2	1.2	78	99.4	2765	4.7		
1918-19.	36	15.7	2	0.6	155	99.5	3248			

Note. The upper figures on the left of each group refer to men, the lower to women; the figures on the right side are the totals.

* Summer school excluded in order that a more true comparison may be made.

† Figures from "Annual report of the President of the University, 1918-19."
1915-16 annual percentages would probably be greater and monthly percentages less if record were complete.

The number of cases of dermatitis from *R. diversiloba* is influenced, not only by the condition of the plant, but also by those conditions which tend to make individuals come in contact with it or with substances coated with its poisonous sap. The clinical statistics, therefore, do not constitute a true index of the virulency of the plant, since the total number of persons exposed is not known. The number of exposed persons in all probability varies at different times of the year, according to the weather conditions, state of other vegetation, individual freedom, etc.

Many attractive wild flowers are found in the same locality with *R. diversiloba* shrubs, such as Clarkias, Godetias, Collinsias, Brodiaeas, and larkspurs (Parsons, 47). John Muir (43) "oftentimes found a curious twining lily (*Stropholieion Californicum*) climbing its branches." The desire to gather spring wild flowers is often greater than the fear of *Rhus diversiloba*. Circumstances thus combine to bring a person in contact with the plant at the time when it is capable of doing the most harm.

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DESCRIPTION OF PLATE II

The material selected for the sections was fixed in a chrom-acetic fixative (1 percent by weight chromic acid in water, 0.5 percent glacial acetic acid by weight). Suitable pieces were then hardened by placing in alcohol of different concentrations in series of 6 percent, 12 percent, 25 percent, 50 percent, and 75 percent, then in xylol and paraffine and finally in paraffine. Sections were then cut on the microtome in series, fastened to clean slides with egg albumen, stained with safranin and Delafield's haemotoxylin, and finally washed in absolute alcohol, in xylol, and mounted in balsam. By this treatment lignified and suberized walls were stained red and cellulose walls violet.

The photomicrographs were made with an electric arc as the source of light. The amount of magnification was calculated by the aid of a ruled slide on the microscope stage and of a rule on the ground glass focusing screen, using the same lenses as were used in the exposure. The photomicrographs have been reduced $2\frac{2}{3}$ times.

A. Transverse section through a lateral leaf rib, showing a resin duct. The resin duct is 0.0053 mm. in diameter. The shortest distance to the bast ring which surrounds the resin duct is 0.0056 mm. $\times 168.4$.

B. Young shoots showing simultaneous expansion of leaves and flower panicles (reduced one fifth).

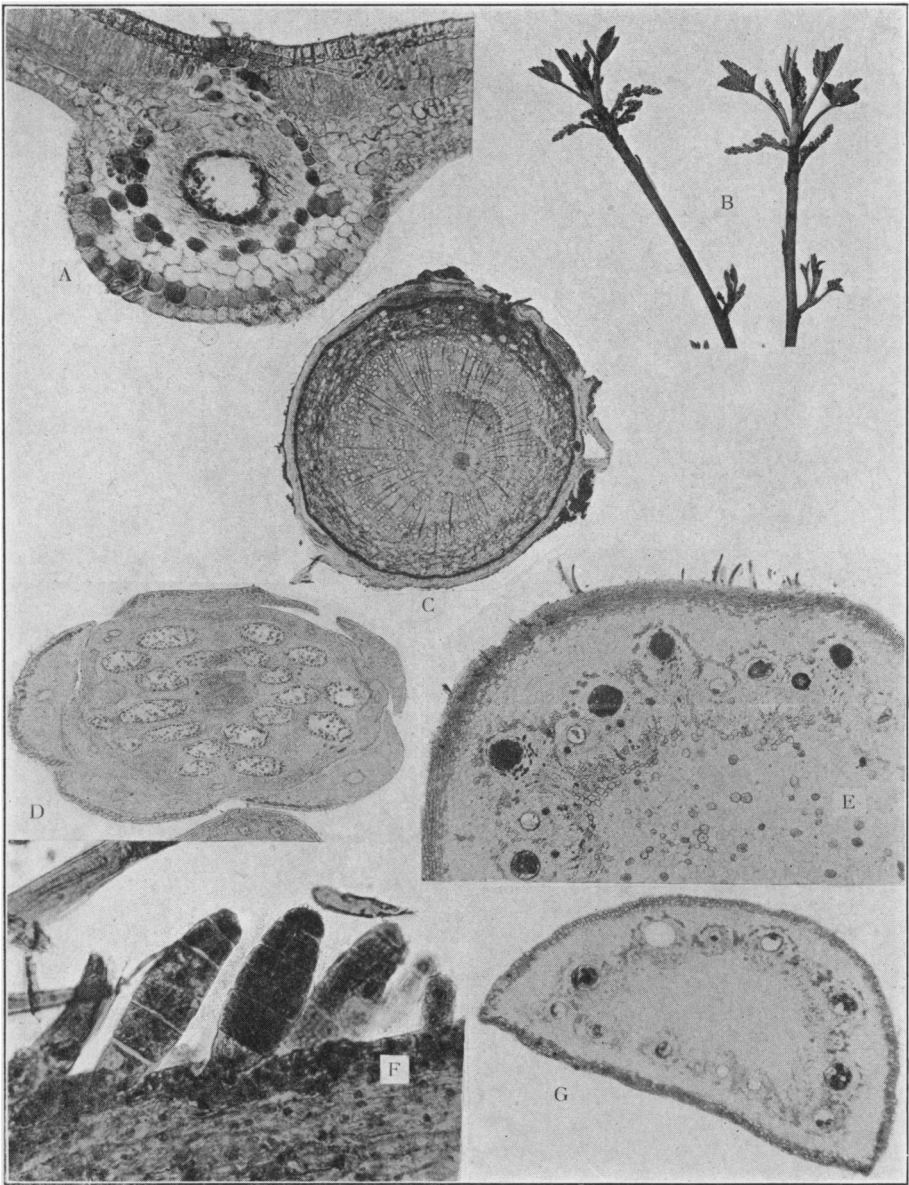
C. Transverse section through a woody root. $\times 7.5$.

D. Transverse section through a staminate flower near the apex showing five calyx leaves with resin ducts, five petals with resin ducts, five anthers showing absence of resin ducts and presence of pollen, and the non-fertile ovule. $\times 40.9$.

E. Transverse section through a green stem, showing epidermis with its trichomes, collenchyma, cortical parenchyma, pericycle with sclerenchyma cells or bast fibers, and thin-walled pericycle parenchyma. $\times 40.9$.

F. Leaf epidermis with attached club-shaped trichomes. (Size of trichomes 0.071 \times 0.0027 mm.) $\times 353.7$.

G. Transverse sections of petiole. The largest resin duct has a diameter of 0.01 mm.; the smallest is 0.0044 mm. in diameter. The largest pith cells are larger than the smallest resin ducts. It is 0.02 mm. from the corner of the petiole section to the bast ring which surrounds the nearest resin duct. $\times 33.8$.



McNAIR: TOXICITY OF RHUS DIVERSILOBA.